METHOD OF MEASURING THICKNESS, METHOD OF PROCESSING IMAGE AND ELECTRONIC SYSTEM PERFORMING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 USC §119 to Korean Patent Application No. 10-2015-0144096, filed on Oct. 15, 2015 in the Korean Intellectual Property Office (KIPO), the contents of which are herein incorporated by reference in their entirety.

BACKGROUND

[0002] 1. Technical Field

[0003] Example embodiments relate generally to image processing, and more particularly to measuring thicknesses of objects and/or layers based on images, processing the images including the objects and/or layers, and/or electronic systems performing such measuring and/or processing.

[0004] 2. Description of the Related Art

[0005] Semiconductor elements are manufactured based on various semiconductor processes. To determine whether the semiconductor processes have been successfully performed or not, physical dimensions (e.g., a thickness) of film materials or thin film layers in the semiconductor elements are measured during and/or after performing the semiconductor processes. The quality and/or productivity of the semiconductor processes or the semiconductor elements may be improved based on feeding back the test results (e.g., measured thicknesses of the film materials or the thin film layers) to the semiconductor processes. Non-contact, non-destructive apparatuses for measuring a thickness of an object using X-ray, sonic wave or light may be used because such apparatuses do not process, destruct, or convert an object to be measured (e.g., a semiconductor substrate). Research for thickness measurement techniques is being conducted to meet the requirement for being more accurate and being capable of measuring more complicated patterns.

SUMMARY

[0006] Accordingly, some example embodiments substantially obviate one or more problems due to limitations and disadvantages of the related art.

[0007] At least one example embodiment provides a method of measuring a thickness of an object and/or a layer capable of efficiently and precisely obtaining the thickness based on an image.

[0008] At least one example embodiment provides a method of processing an image capable of being used in the method of measuring the thickness.

[0009] At least one example embodiment provides an electronic system capable of performing the method of measuring the thickness and/or the method of processing the image.

[0010] According to some example embodiments, a method of measuring a thickness may include obtaining an original image of a structure, the structure including a first layer, the first layer including a first boundary and a second boundary, the original image including an image of the structure having the first layer, the second boundary being substantially indistinguishable in the original image. The method may include extracting the first boundary of the first layer in the original image, converting the original image into a first image based on the extracted first boundary, generating a second image, based on filtering the first image, extracting the second boundary of the first layer in the second image, and calculating a thickness of the first layer based on the extracted second boundary in the second image.

[0011] Extracting the first boundary of the first layer in the first image may include detecting a plurality of boundary points in the original image based on grayscale value changes in the original image, and determining the first boundary as a line extending through the plurality of boundary points.

[0012] Detecting each boundary point in the original image based on grayscale changes in the original image may include determining that a difference between a grayscale value of a given boundary point and a grayscale value of a first point adjacent to the given boundary point is greater than a threshold grayscale value.

[0013] Converting the original image into the first image may include identifying a target region in the original image based on the extracted first boundary in the original image, the target region being associated with the structure and the first layer. Converting the original image into the first image may include mapping a plurality of boundary points in the original image into a plurality of axis points in the first image, the plurality of boundary points corresponding to the first boundary in the original image. Converting the original image into the first image may include obtaining the first image by changing arrangements of a plurality of partial images in the target region based on the plurality of axis points such that the plurality of axis points define a line extending substantially in parallel with an axis of the first image.

[0014] The plurality of boundary points may be nonlinearly arranged in the original image, the plurality of axis points may be linearly arranged in the first image, and a first linear line including the plurality of axis points is substantially parallel with a first direction, and the plurality of partial images may be arranged in the first image along a second direction crossing the first direction.

[0015] The plurality of boundary points may be arranged with a circular shape or an elliptical shape in the original image.

[0016] Generating the second image may include dividing the first image into a plurality of subregions and performing an averaging operation on each of the plurality of subregions to generate a plurality of averaged subregions, such that the second image includes the plurality of averaged subregions.

[0017] The plurality of axis points may be linearly arranged in the first image, and a first linear line including the plurality of axis points is parallel with a first direction. Each of the plurality of subregions may have a first side extending in the first direction and a second side extending in a second direction that is substantially perpendicular to the first direction. The second side may be shorter than the first side.

[0018] The averaging operation may be performed based on a Gaussian filter.

[0019] The method may include removing noise from the first image to at least partially generate the second image.

[0020] The method may include removing noise from the first image based on a domain transform filter.